VOL. 14, NO. 21, NOVEMBER 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2019 Asian Research Publishing Network (ARPN). All rights reserved.

www.arpnjournals.com

STUDY OF LANDSLIDES IN MEDITERRANEAN BYPASS ROAD: CASE OF JEBHA

Soukaina Meziane, Lahcen Bahi and Latifa Ouadif
L3GIE Laboratory, Mohammadia Engineering School, Mohammed V University, Rabat, Morocco
E-Mail: soukaina.meziane@gmail.com

ABSTRACT

The Mediterranean Bypass road in the North of Morocco is frequently subject to landslides. In this paper, the case of Jebha is studied to deduce trigger factors and then to suggest reinforcement solutions. Between the PK5+300 and PK6+000, a slip of the slope is occurred even if it was stabilized during project work. To analyse soil consistency, geotechnical recognition is established. Based on material characteristics, slope mechanism model is done using 2D finite elements modelling using Plaxis software. Results show that vulnerable geotechnical nature of materials, rugged topography and saturated soil in El Jebha cause slippage. Therefore, to ensure safe traffic flow comfortably, solutions of reinforcement are proposed.

Keywords: jebha, landslide, modelling, mediterranean bypass, stability.

INTRODUCTION

Jebha is located on the north Rif of Morocco belonging to the Chefchaouen Province. The area knows a Mediterranean climate semi-arid with wet winter and dry and warm summer. The study area is a mountainous area marked by variable altimetry and by tender deposits with lithological and tectonic conditions combined with the recent seismic activity, which affect the stability of slopes and generate landslides in this portion of the Mediterranean coastline (Maurer [1] and Meziane [2]). In addition, the effect of precipitation is to be taken into consideration. In fact, the amount of the annual rainfall is effective only with the conjunction, during the same rainy year of intensity and the pace of precipitation (Mokhtari [3]). As well, this dynamism represents, in this region, a handicap to the realization of potential development projects.

This work concerns the study of landslides in the area of El Jebha. In fact, a section between PK5+300 and PK6+000 of the Bypass Mediterranean is subject of a landslide. Therefore, a detailed description of the area and the consistency of the soil on the section is first presented. Then, taking into account the characteristics of the materials, the mechanism of the landslide is analyzed through a numerical finite elements model using the PLAXIS software [4]. Finally, if later slippage occurs, several solutions are recommended.

DESCRIPTION OF THE SITE

On the Mediterranean Bypass, the road alignment is often in laces (Figure-1) at different altitude, higher in rising track and lower in descending way. Alternatives to this type of projects are tunnels but the project for the development of the Bypass road will be more expensive especially that the road crosses an important linear which connects the entire region of the Rif. Because of the rugged topography and the vulnerable geotechnical nature of soil, the construction of the bypass road between 2007 and 2012 was particularly difficult and the stabilization of slopes was crucial during the execution of the work. In this article, the section between the PK5+300 and PK6+000 from El Jebha is studied. The route alignment is presented in laces with traffic of 1684 cars per day. Despite the slope was stabilized with 2/3 angle of repose with berm without bolting because the soil was considered rocky, a landslide has recently triggered.

This study initiates firstly geotechnical recognition of soil then analyses characteristics of the field to deduce the factors triggers of the landslide. On the basis of the geotechnical investigation, a finite element model is established for modelling the mechanism of the landslide and to predict the degree of danger that can cause the slip on the road and its users.

ARPN Journal of Engineering and Applied Sciences
©2006-2019 Asian Research Publishing Network (ARPN). All rights reserved.

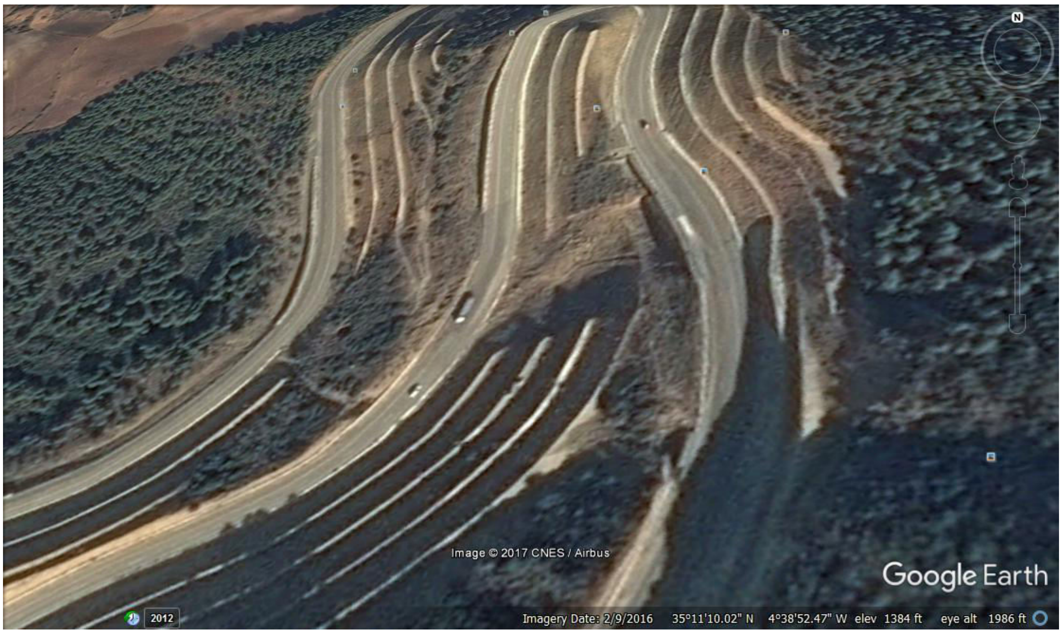

Figure-1. Extract of satellite image of the area of study.

The characteristics of the soil and triggering factors of instability

The main factors of instability are the mechanical characteristics of materials (cohesion and friction), the particle size distribution (the fine fraction FF) and the plasticity index IP (Gokceoglu, [5]; Remondo [6]; Faleh [7]; Labriki [8]). To deal with land instabilities, a geotechnical study is required. In fact, on 120 ml, four boreholes are conducted to the PK5 + 762, PK5 + 846, PK5 + 897 and PK5 + 950 of the Mediterranean route from El Jebha.

Table-1 summarizes the characteristics of soil extract from boreholes.

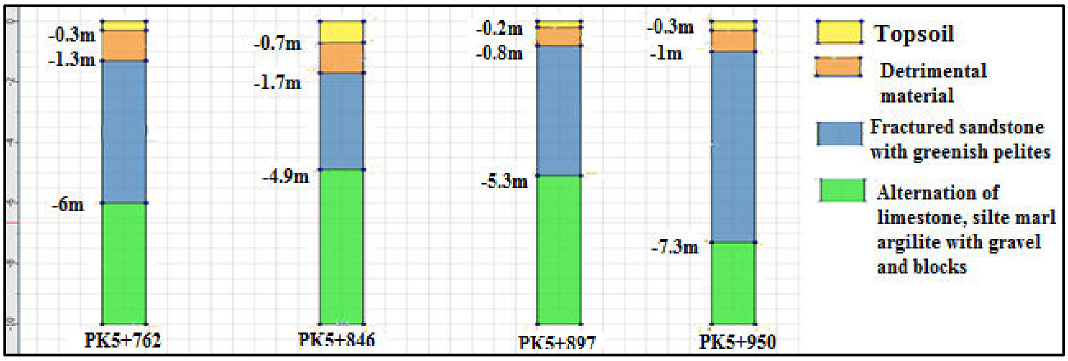

Figure-2. 4 Boreholes carried out respectively at PK 5 + 762, PK5 + 846, PK5 + 897 and PK5 + 950 of the Mediterranean road from El Jebha.

VOL. 14, NO. 21, NOVEMBER 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2019 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

Table-1. Characteristics of soil extract from boreholes.

Borehole No.	Borehole at KP	Depth (m)	Soil nature	AtterbergLimit		Particle size analysis				Water content	Φ	C
				Wl	Ip	%<0.08 mm	%<2 mm	%<50 mm	Dmax (mm)			
1	5+762	-3.9	-	-	-	-	-	-	-	9.3	18	10
		-4.9	sandstone presence of yellowish sandy silt	NM	NM	23.5	62	78.7	100	7		
		-10	Alternation of limestone, marl, argillite and siltite	-	-	-	-	-	-	-	32	30

Borehole No.	Borehole at PK	Depth (m)	Soil nature	AtterbergLimit		Particle size analysis				Water content	Φ	C
				Wl	Ip	%<0.08 mm	%<2 mm	%<50 mm	Dmax (mm)			
2	5+846	-2.4	-	-	-	-	-	-	-	18.7	18	10
		-3.4	-	-	-	-	-	-	-	10.2		
		-4.9	Sandy silt sandstone ++ trace of Marne	29	13	17.9	34.6	92.1	80	5.1		
			Alternation of limestone, marl, argillite and siltite	-	-	-	-	-	-	-	32	30
3	5+897	-1.9	-	-	-	-	-	-	-	11.3	18	10
		-3.5	-	-	-	-	-	-	-	5.5		
		-3.8	-	-	-	-	-	-	-	4.9		
		-5	Sandstone +sandy silt	31	14	10.7	22.4	86.1	100	3.4		
		-10	Alternation of limestone, marl, argillite and siltite	-	-	-	-	-	-	-	32	30
4	5+950	-1.7	-	-	-	-	-	-	-	7.3	18	10
		-5.10	-	-	-	-	-	-	-	5.3		
		-7.3	Altered sandstone +trace of Marne	41	23	13.6	23.5	77.3	100	7.7		
		-10	Alternation of limestone, marl, argillite, siltite	-	-	-	-	-	-	-	32	30

The landslide is located on a mountainous area (β=30%) where the soil is made up of soft little-plastic to plastic materials with presence of the fine fraction. The analysis of the soil characteristics is summarized in the Table-2.

ARPN Journal of Engineering and Applied Sciences
©2006-2019 Asian Research Publishing Network (ARPN). All rights reserved.

Table-2. Summary of the analysis of geotechnical characteristics.

Factor		Class	Description
Cohesion		c'=< 10	Soft material (Low Cohesion)
		25< c'=<45	Solid material (average cohesion)
Friction and slope		β =30° > φ=18	Area at risk of instability
		β =30° < φ=32	Area of low stability
Fine fraction (%<2mm) to survey no.	1	FF =62 >= 35%	Behavior of fine fraction
	2	12 <FF=34.6 < 35%	Sandy soil and gravel with presence of the fine fraction
	3	12 < FF=22.4< 35%	Sandy soil and gravel with presence of the fine fraction
	4	12 < FF=23.5< 35%	Sandy soil and gravel with presence of the fine fraction
Plasticity index for the ground No.	2	05 < ip=13 <=15	Little plastic ground
	3	05 < ip=14 <=15	Little plastic ground
	4	15< ip=23 <=40	Plastic

Thus, the analysis of the components of the soil gives that approximately two layers of soils can compose the soil:

- A middle-altered layer of 5m in thickness constituted by the detrital material with yellowish and reddish silt based on sandstone highly fractured with presence of greenish pelites. This layer is highly fragile. In the presence of water, the risk of slipping and the gully erosion increases and the slope may occur. As well, their stabilization and the remediation of slope becomes crucial to prevent the infiltration of water to the deeper layers causing landslides in large scale.
- A substratum constituted by an alternation of limestone, marl, argillites and siltstones with presence of gravel and blocks.

SLIP MODELLING BETWEEN THE PK5+300 AND PK6+000

The slop modeling isdone by PLAXIS 2D v8 [4]. The software is a finite element package for the analysis of deformation and stability in geotechnical engineering. Many studies have used PLAXIS in 2D deformation modeling (Akhssas [9]; Zheng [10-11]; Baba [12]; Ouadif [13]).

A. Analysis of current state

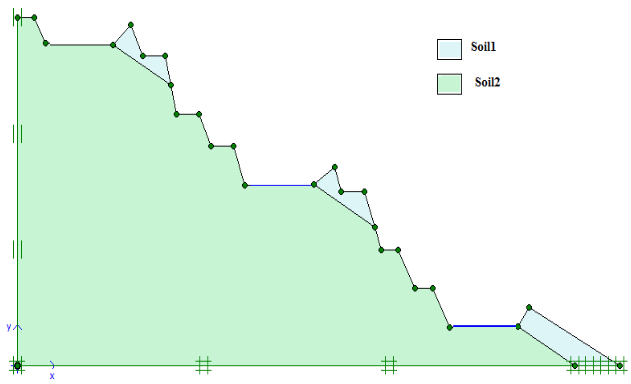

Figure-3. Profile of the slope.

The profile of the slope shows a 2/3 angle of repose where the road cut the slope on three sections with a charge due to maximum traffic estimated during the simultaneous passage of heavy weight truck with three axles.

From the geotechnical campaign above, the necessary ground characteristics for modeling are summarized in the following Table-3:

Table-3. Summary of soil 1 and soil 2 characteristics.

	γ_{unsat}(KN. m3)	γ_{sat} (KN. m3)	K (m.s)	Γ	E (MPa)	C (KPa)	Φ (°)
Soil 1	19	20	1. E-4	0.3	17	10	18
Soil 2	20	23	1. E-4	0.3	50	30	32

©2006-2019 Asian Research Publishing Network (ARPN). All rights reserved.

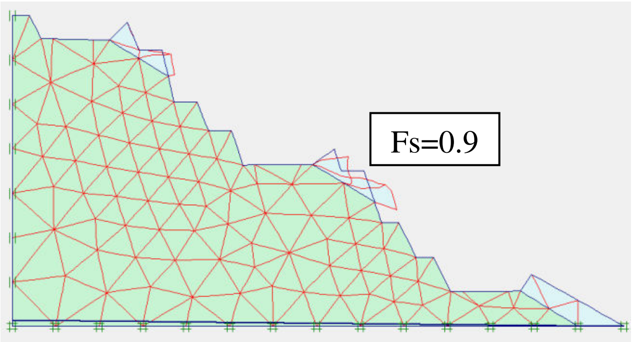

Figure-4. 2D Deformation mesh of slope by Plaxis V8.

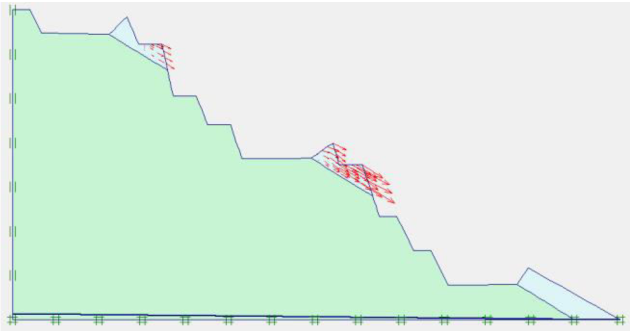

Figure-5. Total displacements.

The slop modeling (Figures 4 and 5) shows that the landslide occurred because of the collapse of the top layer scarped of 2/3 angle of repose. As the silty material is laid on the fractured sandstone and due to rainwater infiltration, the mechanical characteristics of the soil become weak because of the abundance of the fine fraction in which the resistance drops when the free water appears during the wet periods. Thus, soft materials pass from plastic state to liquid state causing the slipping under its own weight.

In case the draining is not addressed correctly, huge ground movements can occur and becomes then a real danger for route and its users.

B. Modeling in the case of non- repair of the slope

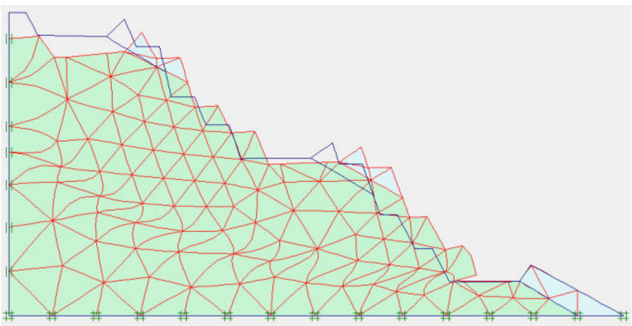

Figure-6. Mesh deformation in the event of non-processing of the Remediation.

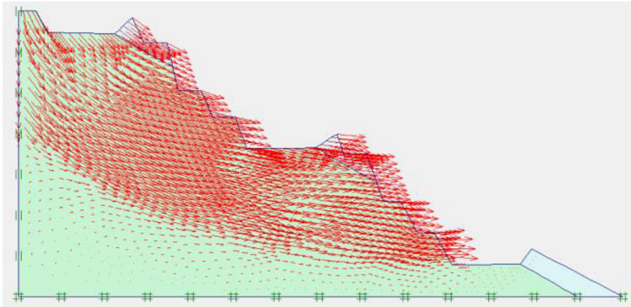

Figure-7. Total displacements if none draining correctly.

The more water continues to infiltrate in deeper layers, the more slip is important (Figures 6 and 7). The presence of tender materials (alternation of limestone, marl, argillites and siltstones) with solid materials (gravels and blocks) on a ground not drained leads that the mechanical characteristics of fine elements become weak and their resistance drops in the presence of water. Therefore, materials pass from the plastic state to the liquid state causing landslide but this time on large scale even in presence of gravel and rock blocs.

DISCUSSIONS

The land stabilization requires a regular maintenance [14-15]. Sometimes, in later slippage, repairing solutions are recommended as follows:

- Need to evacuate and purge the remolded materials
- Excavate the bedrock to support the alternative materials
- Rebuild the slope 1/1 of repose angle from the bottom to the top by the establishment of rockfill, which plays the role of filter and blocks of fine elements
- Requires restoring berms continuity to ensure storm water flow
- To restore water flow on berms, the voids between the riprap will be filled by Sandy gravels and then covered by large concrete
- If important slip occurs, a stabilization study must be redone to take account of the new conditions by adopting the most appropriate solution without on-sizing the workings.

CONCLUSIONS

The slip between the PK 5+300 at PK6+000 of the Mediterranean Bypass from El Jebha is only an example of landslides in the Rif region. Because of the vulnerable geotechnical nature of ground, its rugged topography, its tectonic activity (overlap of two normal faults), its saturated and watered soil (high precipitation and important presence of sources), El Jebha knows land instabilities. Therefore, to ensure safe traffic flow comfortably, the maintenance of supporting walls and storm water drainage are important.

©2006-2019 Asian Research Publishing Network (ARPN). All rights reserved.

ACKNOWLEDGEMENTS

The authors thank the anonymous readers for their comments and suggestions that have helped to improve the quality of manuscript.

REFERENCES

[1] Maurer G. 1968. The Rif Mountains Central; geomorphological study. Trav. Inst. Sci., Series Vol. & Géogr. Phys., 14, rabat. p. 499.

[2] Meziane S., Bahi L., Ouadif L. (2018). Differential Synthetic Aperture Radar Interferometry for Land Movements Mapping Case of El Jebha (North of Morocco), International Journal of Civil Engineering and Technology. 9(5): 105-113.

[3] Mokhtari N., Mrabet R., Leebailly P. & Bock L. 2013. Spatialization of the bioclimats, the aridity and the floors of vegetation of Morocco. Moroccan Review Agronomic Sciences and veterinary products. 2, 50-66.

[4] PLAXIS. 2004. Finite Element Code for Soil and Rock Analyses. PLAXIS-2D Version 8, Reference Manual, Edited by Brinkgreve, *et al*., DUT, the Netherlands. www.plaxis.nl

[5] Gokceoglu C. 2001. Discussion on landslide hazard zonation of the Khorshrostam area, Iran by A. Uromeihy and M. R. Mahdavifar, Bulletin of engineering geological environment, 58, 207-213. Bulletin of engineering geological environment. 60, 79-80.

[6] Remondo J., Gonzàlez-Diez A., Dìaz of Teràn J. R., Cendrero A., 2003. Landslides susceptibility models utilising spatial data analysis techniques. A case study from the Lower Deba Valley, Guipùzcoa (Spain). Natural hazards, 30, 267-279.

[7] Faleh A., Sadiki A., Akdim B. & Haloui B. 2002. Application of mineralogical analyzes and geotechnical clays in the study of landslides: examples of central Prérif (northern Morocco). Pap. Géogr. Univ. Murcia (Spain). 35, 115-128.

[8] Labriki A., Chakiri S., Nouaim W., Allouza M., Ezzayani J. 2016 methodological approach for the assessment of susceptibility of the slopes to landslides of Terrain Par a model density of the hazard; Application to the sector of Boujibar Al Hoceima (GIR, Morocco). European Scientific Journal Nov 2016 vol. 12 no. 32

[9] Akhssas A., Bahi L., Lahmili A., Ouadif L. 2011. Study of the stability of rock slope. Canadian Journal on Scientific and Industrial Research. 2(2): 35-39.

[10] Zheng H., Liu D. F., Li C. G. 2005. Slope stability analysis based on elastoplastic finite element method. Int. J. Numer. Meth. Eng. 64, 1871-1888.

[11] Zheng Y. R., Zhao S. Y., Kong W. X., Deng C. J. 2005. Geotechnical engineering limit analysis using finite element method. Rock Soil Mech. 26, 1, 163-168.

[12] Baba K. BahiL. Ouadif L. Akhssas A. 2012. Slope Stability Evaluations by Limit Equilibrium and Finite Element Methods Applied to a Railway in the Moroccan Rif. Open Journal of Civil Engineering. 2. 27-32.

[13] Ouadif L. Bahi L. Baba K. Akhssas A. 2012. Study of Stability of a Highway Fill Application of the Analytical and the Finite Elements Methods. International Journal of Engineering Research and Applications (IJERA). 2(1): 904-910.

[14] Meziane S., Bahi L., Ouadif L. (2019). Automatic Recognition of Pavement Degradation: Case of Rif Chain. In: El-Badawy S., Abd El-Hakim R. (eds) Recent Developments in Pavement Design, Modeling and Performance. GeoMEast 2018. Sustainable Civil Infrastructures. Springer, Cham. https://doi.org/10.1007/978-3-030-01908-2_11

[15] Meziane S., Bahi L., Ouadif L. (2019). Automatic Recognition of Land Instability. International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-2, July 2019 https://doi.org/10.35940/ijrte.B1967.078219